2006 Irrigated Land Classification for the Eastern Snake Plain Aquifer

Introduction

IDWR is revising its Eastern Snake Plain Aquifer (ESPA) groundwater model. As part of that revision, the Geospatial Technology Section was asked to generate a new digital classification of the irrigated land within the boundary of the ESPA model. Water from irrigated land is a source of significant recharge to the aquifer, and is one of the factors that determines the accuracy of the model's predictions. The new classification would replace the old classification which is circa 1992. The area of the Eastern Snake Plain is illustrated in Figure 1.

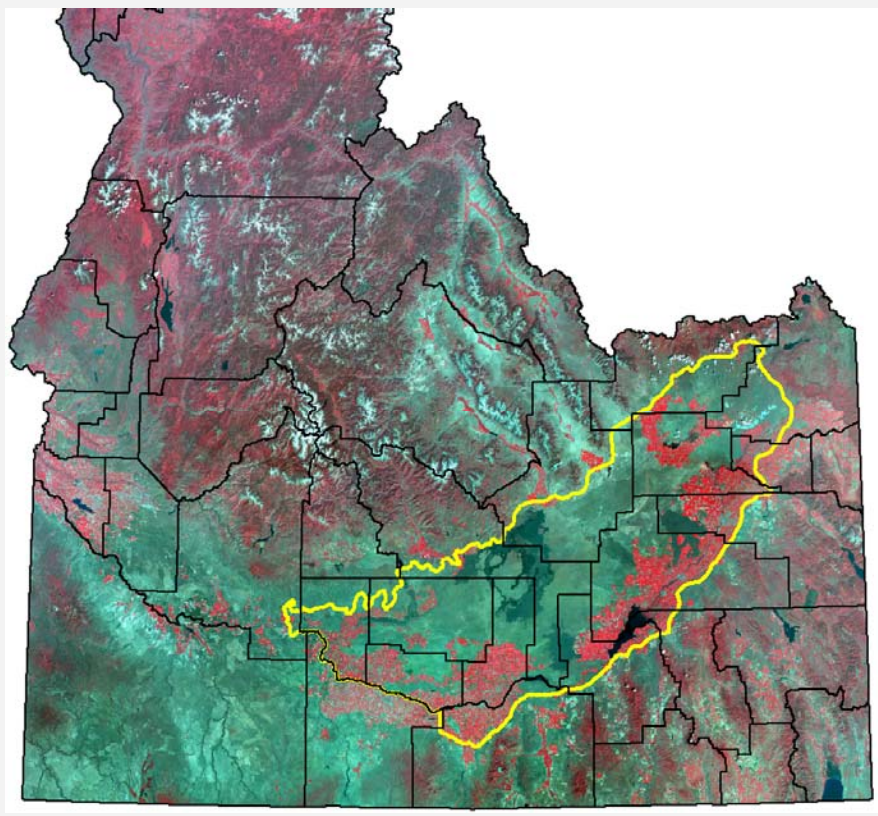

Figure 1. The boundary of the Eastern Snake Plain Aquifer, in yellow.

Several approaches to the classification were considered and for various reasons, rejected. The primary goals of the classification were to delineate agricultural land as accurately 1) as precisely as possible, 2) as accurately as possible, and 3) as recently as possible.

The classification scheme chosen achieves all three goals by using a combination of computer processing and human interpretation operating on both Landsat satellite data and on digital aerial photography acquired through the National Agricultural Inventory Program (NAIP). All image data is from the year 2006.

In conjunction with the image data, IDWR analysts used Common Land Unit (CLU) polygons of individual fields that were digitized from a combination of 2004 and 2006 NAIP imagery by the Farm Services Administration (FSA). Although FSA will allow access to CLU polygons, they deny all requests for access to the associated attribute data, including the land-cover codes. IDWR, therefore, used the unattributed CLU polygons. The CLU polygons were used because they constitute an existing, recent, highly-detailed, vector dataset that IDWR could attribute as irrigated or non-irrigated relatively easily. Figure 2 shows CLU polygons superimposed on NAIP image data.

Figure 2. Common Land Unit (CLU) polygons in black superimposed on National Agricultural Inventory Program (NAIP) image data.

CLU Data

FSA created the CLU polygons as part of its crop compliance responsibilities. While the CLU data are extensive, and have been finished for all the counties on the ESPA, the polygons themselves do not fit perfectly IDWR's needs. An examination of CLU data at the beginning of the project revealed the need for editing the polygons, sometimes in some detail. The project deadline precluded complete editing, but even so, the CLU very nearly fit IDWR's needs.

The Classifier

IDWR used a 3-step classifier to map irrigated land on the ESPA. The first step used Landsat satellite data, the second step used a combination of Landsat and NAIP digital photography, and the 3rd step used NAIP photography and CLU data.

The First Step

The first classification step used Landsat satelltite data exclusively. Landsat is a medium resolution satellite with square pixels that are 30 meters on each side. IDWR used 3 dates of Landsat data: June 20, 2006, July 22, 2006, and August 7, 2006. Those dates were used because they were available at IDWR for processing with the METRIC evapotranspiration model.

As part of the METRIC processing, each scene in transformed to produce a vegetation index, specifically the normalized difference vegetation index (NDVI), which is computed as

$$\frac{\text{band 4} - \text{band 3}}{\text{band 4} + \text{band 3}}$$

The actual computation is more complex, and involves conversion of the raw digital numbers in the image to radiance. This is done as part of the METRIC processing to process a consistent set of data from scene to scene.

The normalized difference is highly correlated with vegetation canopy characteristics, including leaf area index. Plotted through a growing season, the normalized difference nicely tracks the development of vegetation.

IDWR transformed all three dates of Landsat data to NDVI, then clustered and classified the data into 255 spectral classes. The 255 spectral classes were superimposed in the Landsat false color images and interpreted to either “irrigated” or “non-irrigated,” producing a Landsat classification of irrigated and non irrigated pixels as illustrated by Figure 3.

The Second Step

The second step in the classification was to overly CLU polygons on the Landsat classification, as illustrated by Figure 4. A simple decision rule was applied that made a polygon irrigated if at least 75% of the area of the polygon was classified by Landsat as “irrigated”. The result of the decision rule on Figure 4 is illustrated by Figure 5.

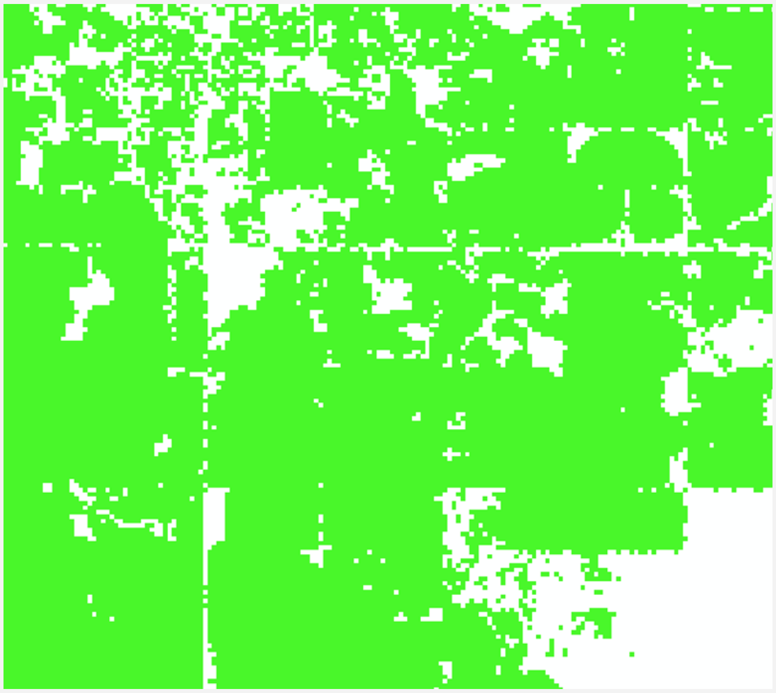

Figure 3. The initial Landsat-based classification output from Step 1 of the classifier. Irrigated land is green

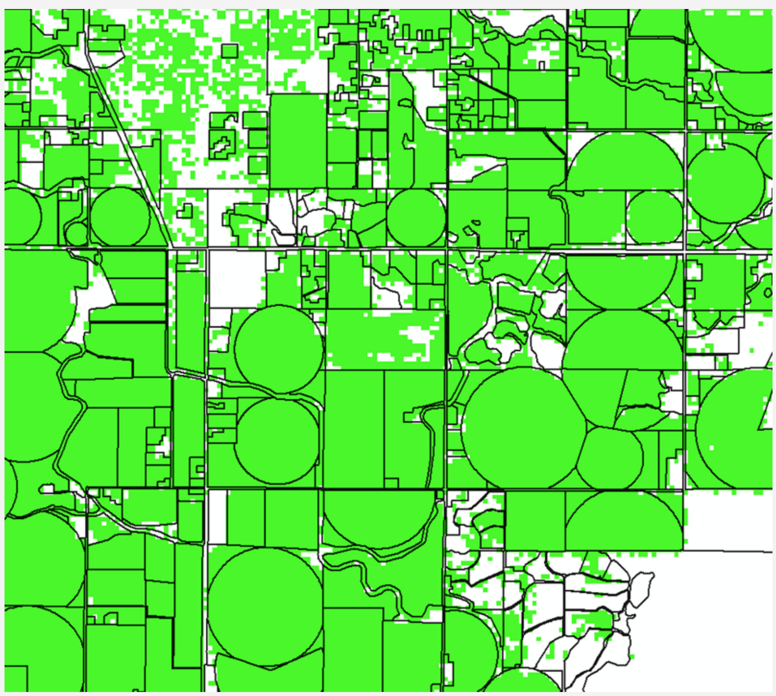

Figure 4. The initial Landsat-based classification output from Step 1 of the classifier with CLU polygons superimposed. Irrigated land is green

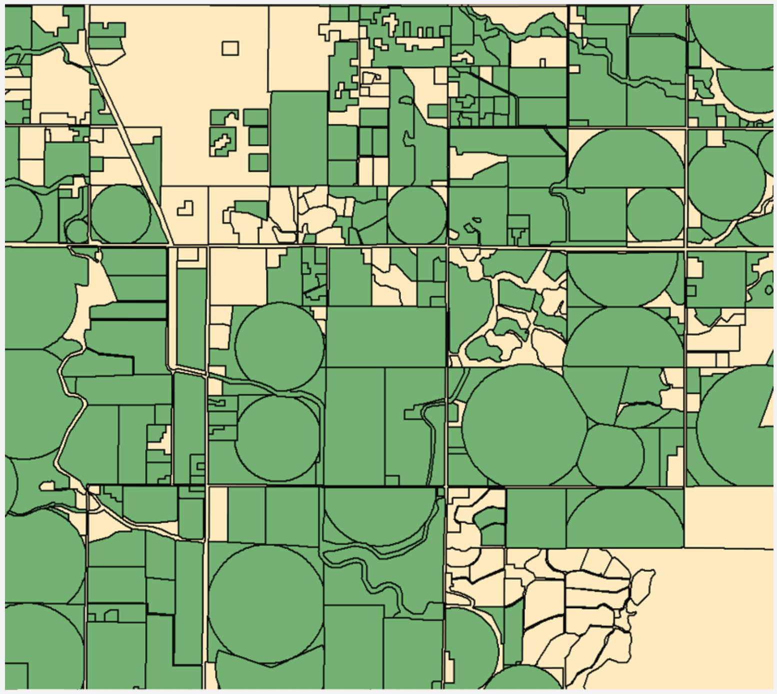

Figure 5. The Landsat-based classification output from Step 2 of the classifier with CLU polygons superimposed and all the CLU polygons classified as irrigated or non-irrigated based on a 75% or greater rule. Irrigated land is green.

The Third Step

The third step was to review the Irrigated-Nonirrigated classification in Figure 4 by superimposing the classified image on top of the 2006 NAIP digital photography. This was done in 2 phases by alternately masking irrigated polygons and then non-irrigated polygons, and then overlaying the masked image sequentially on all available dates of Landsat data, one date at a time, and on the NAIP.

IDWR used three dates for the initial Landsat classification because the NDVI transformation had been run on only those dates as part of the METRIC processing. The editing of the classification was done using all available Landsat dates, which are summarized by Tables 1 and 2.

Figure 6 shows masked irrigated polygons on a Landsat image. What is not masked is classified as non-irrigated. Clearly, there are some irrigated fields being classified as non-irrigated. Those misclassifications were corrected by simple editing, and the process was repeated for each date of Landsat data available, and for the NAIP (Figure 7).

Orbital Path 40

Landsat 5	Landsat 7
May 3	April 25
May 19	August 31
June 20	
July 22	
August 7	
September 8	
September 24	
October 10	

Table 1. Landsat scenes dates for Orbital Path 40

Orbital Path 39

Landsat 5	Landsat 7
April 26	April 4
May 12	October 11
June 13	
July 15	
August 16	
September 1	
October 3	

Table 2. Landsat scenes dates for Orbital Path 39

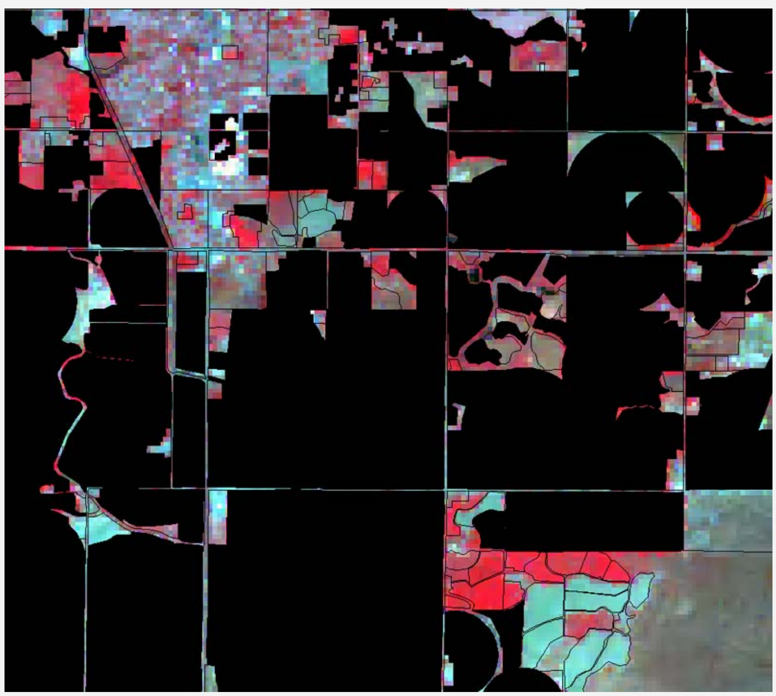

Figure 6. Irrigated polygons masked to black and superimposed on Landsat data from May 19, 2006.

The analysis done in Step 3 revealed that many fields that were classified as non-irrigated using the three dates were actually irrigated in the May and/or September-October time-frame. Although these fields were not classified as irrigated by Steps 1 or 2, they were classified as irrigated by Step 3

The entire classification could have been done using just Step 3, but it would have taken longer and been more tedious. The first two steps were designed to classify quickly those fields that the computer could readily identify as irrigated. The third step was designed to use a human interpreter to make subtle decisions that were beyond the meager intelligence of the software, and to correct any classification errors made by the software. Figure 9 shows an example of one kind of those errors. Steps 1 and 2 resulted in small polygons of residential land being classified as irrigated. In Step3, those polygons were changed from irrigated to a third class not used in the first 2 steps: residential.

The residential class was added because there is generally irrigation occurring in residential areas, but that irrigation is not as intense as the irrigation of agricultural land. The residential class captures that less-intense irrigation.

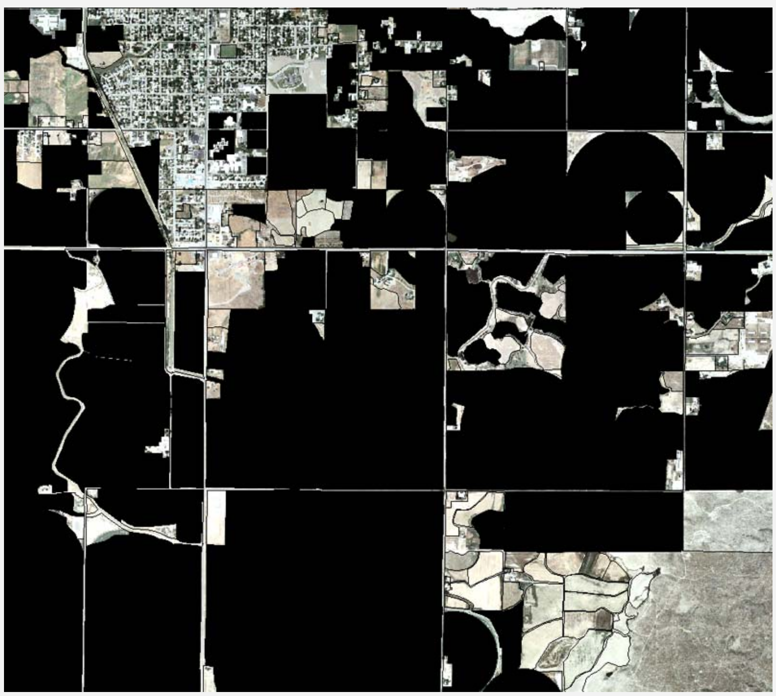

Figure 7. Irrigated polygons masked to black and superimposed on 2006 NAIP image data.

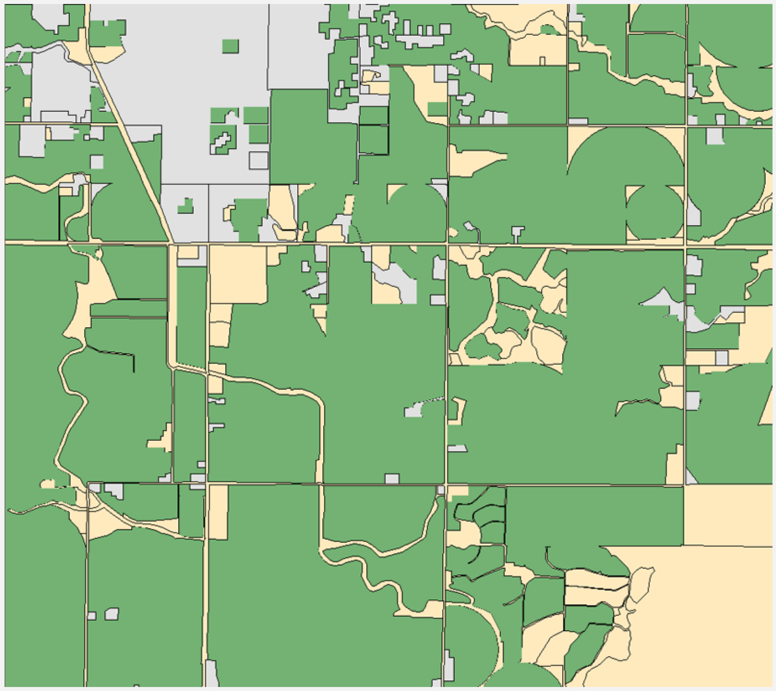

Figure 8. The final, edited classification with irrigated in green, non-irrigated in beige, and residential in gray.

Figure 9 . Non-Irrigated mask on NAIP. Arrows point to some residential land classified as irrigated. Those polygons are changed during editing.

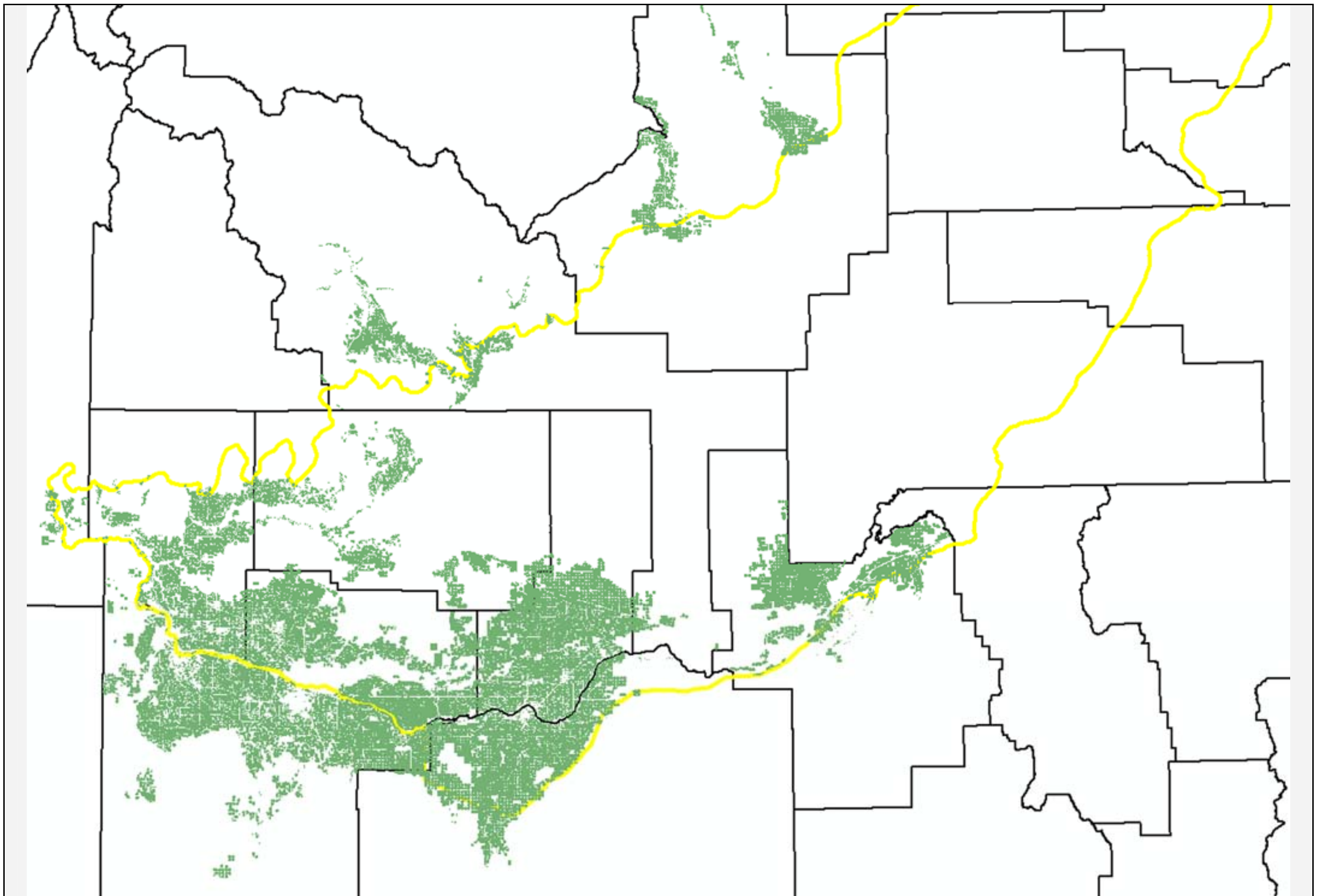

Figure . Status of the irrigated land classification on the western part of the Eastern Snake Plain Aquifer, as of November 1, 20080.

Draft 11/7/2008
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